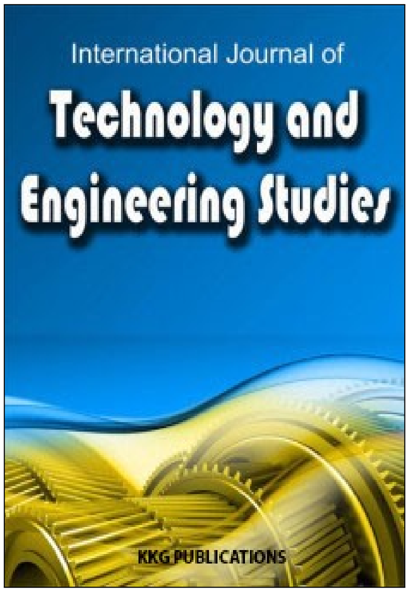

Key Knowledge Generation

Publication details, including instructions for author and subscription information:
http://kkgpublications.com/technology/

Evaluation of Mobile Communication Network Performance

OSAHENVEMWEN O. A.

Faculty of Engineering and Technology, Ambrose Alli University, Ekpoma, Edo State, Nigeria

Published online: 22 February 2017

To cite this article: O. A. Osahenvemwen "Evaluation of mobile communication network performance," *International Journal of Technology and Engineering Studies,* vol. 3, no. 1, pp. 09-19, 2017.
DOI: https://dx.doi.org/10.20469/ijtes.3.40002-1

To link to this article: http://kkgpublications.com/wp-content/uploads/2017/03/IJTES-40002-1.pdf

KKG PUBLICATIONS

International Journal of Technology and Engineering Studies
vol. 3, no. 1, pp. 09-19, 2017

IJTES

EVALUATION OF MOBILE COMMUNICATION NETWORK PERFORMANCE

OSAHENVEMWEN O. A. *

Faculty of Engineering and Technology, Ambrose Alli University, Ekpoma, Edo State, Nigeria

Keywords:
Quality of Service
Received Signal Strength (RSS)
Subjective Method

Received: 22 October 2016
Accepted: 12 December 2016
Published: 22 February 2017

Abstract. This study presents an evaluation of mobile communication network performance carried out in Nigeria; it aims to evaluate the performance of mobile communication network based on Quality of Service parameters. The Quality of Service considered blocked calls, dropped calls, speech quality, and Received Signal Strength (RSS) in three different mobile communication networks with the following nomenclature NET A, NET B and NET C in Nigeria. The RSS data were obtained using TECNO mobile equipment, with model number TECNO N3 and Andriod Version 2.3.5, with RF network tracker software used to evaluate the Mobile communication network providers operating on the 900/1800 MHz spectrum in Nigeria. Also, subjective measurement methods using Mean Opinion Score (MOS) were deployed to determine the speech quality level. The subjective technique became accomplished in a quiet location at diverse instances, with endorsed sentences at one-of-a-kind durations respectively for the three cell networks below consideration. The investigation was from June 2014 to July 2015 at Ambrose Alli University campus, Ekpoma. The male and female speech quality was examined; also, comparison analysis became finished from various networks to decide their speech fine, using different statistical techniques such as Root Mean Square Error (RMSE) and Correlation Coefficient. Additionally, different reasons for drop calls and low (poor) speech high-quality degrees were highlighted. It is determined that the full average RMSE value from the male speech excellent received from the three networks taken into consideration is 0.601. In contrast, the correlation coefficient value got between the male and female quality of speech was invariance. Also, Net A has higher (better) speech quality than Net B and Net C. In addition, speech distortions have led to a high number of drop calls in mobile communication networks. These findings will help in improving mobile communication in Nigeria.

INTRODUCTION

The benefits of mobile communication network in enhancing any country's economic growth cannot be over emphasized. This basic technology has contributed immensely to human development and capacity building in terms of employment, training of human empowerment, mobile communication network that helps in sharing and gathering of information etc. In recent times, there are various mobile communication standards such as GSM, CDMA 20001X, EGDE, GPRS, UMTS and LTE with various acronyms of different generation attached. The ideal behind different mobile communication standards came into existence on the basis of improving technical performance leading to a better QoS in the mobile communication network [1], [2] and [3].

In addition, the variation in mobile communication standards, with different mobile networks vendor and mobile operators in place, the subscribers still experience dwindling quality of service. In recent times, the number of subscribers in Nigeria, complaining of being short change by mobile communication operators in Nigeria is on the increase. Therefore the mobile communication network must be subjected to a litmus test by evaluating the QoS parameters to determine the performance of quality of service being rendered to the terming population of Nigeria. In recent times, subscribers have witnessed bad quality of service expressed due to poor speech quality, block calls, drop call and low signal level from the mobile communication networks. Due to this poor speech quality or distortion in speech, subscribers are forced to terminate their calls hereby increasing the number of calls dropped and decide to redial calling party in attempt to obtain good quality of speech. Subscribers are always dissatisfied with the speech (digital audio) quality produced through speaker telephones, earphones and mobile phones etc. [4]. Speech signals transmitted through telecommunication systems suffer from significant call quality degradation caused by channel noise, interferences, echo, codec used, speech level, noise level and bit error ratio. These impairments have become a major setback in mobile communication system. Every language adopted by the humans inherent some meaningful elements which have some meanings. Such type of element is denoted as phoneme. Phoneme is utilized and considered significant to differentiate between two words. The human vocal tract's philosophy is dependent upon several limitations of speaker like pitch of voice, the accent of speaker and rate of speaking. Creation of

*Corresponding author: Osahenvemwen O. A.,
†Email: Osahenvemwenaustin@ymail.com

pressure waves with the help of airflow is an element of speech. Such styles of waves are devised within the lungs of speaker exhales. The vocal fold inside the larynx can open and close quasi-periodically to break this airflow. The end result is voiced speech, that is characterised through it periodicity. Vowels are the maximum prominent instance of voiced speech. In addition to periodicity, vowels also exhibit surprisingly excessive power in evaluation with all different phoneme lessons. This is due to the open configuration of the vocal tract for the duration of the utterance of a vowel, which permits air to skip with out restriction. The normal human speech level falls between 55dB and 65 dB (measured at a distance of 1 meter from the speaker) [5], [6], [7].

Speech exceptional is a complicated psycho-acoustic phenomenon within the manner of perception. As such, it's miles always subjective (anybody interprets speech high-quality in a specific way). Therefore speech quality is generally expressed as a MOS. Speech quality measurement provides a measurement basis in order to specify the requirement that network operators have to fulfill [8], [9] [10].

In telecommunications, mainly in fradio, signal energy refers back to the significance of the electrical area at a reference point that may be a substantial distance from the transmitting antenna. The signal strength should not be less than, -100 dBm (considered weak coverage), -50 dBm is considered to be full signal strength. Continuous upgrade of signal strength prediction procedures and simplification of link produces can lead to optimization of network performance estimations, minimization of interference problems and efficient functioning of communication channels [11], [12], [13], [14], [15].

Background Study

The modeling of mobile communication network is divided into three main elements or sectors in Fig. 1 which includes; traffic user (demand), structure (hardware) and operational strategy (software).

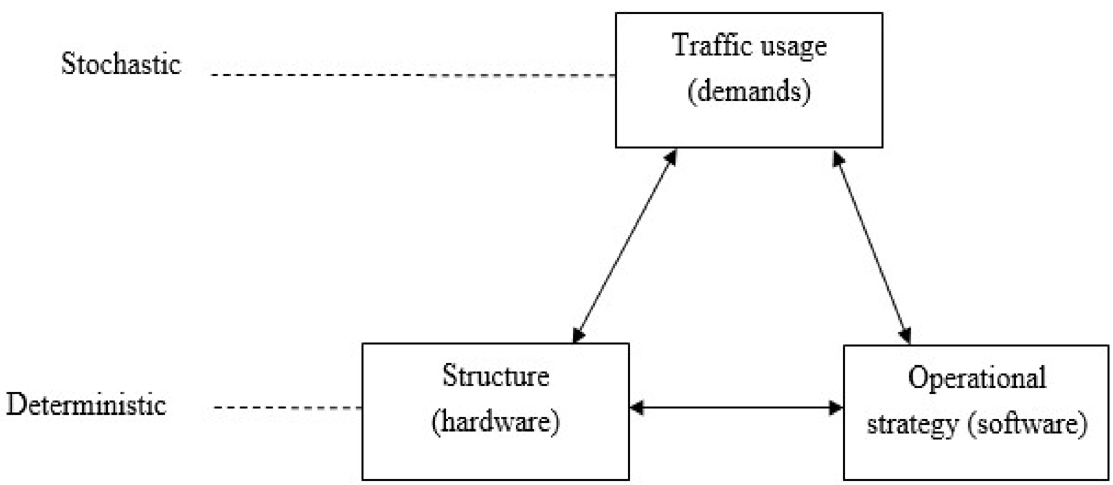

Fig. 1. Mobile communication system

In Fig. 1, the mobile communication system is made up of three major components; these include; the traffic usage (traffic demands), which is random in nature, structure (hardware) and operational strategy, which are also deterministic components.

Structure: It's considered as the hardware in the system; example is identical channels (servers, trunks, slots) working in parallel. These channels are referred to as homogenous group.

Strategy: It's referred to as the queue discipline, the order or manner in which customers are selected for service [18]. Example of queues discipline are as follows: FirstCome-First-served (FCFS), Last-Come-First Served (LCFS), Service in Random Order (SIRO) and Priority service. A call arriving at the system is accepted for service if at least one channel is idle. A call cannot be blocked if the system is free, except all channels are busy in the system.

Traffic is triggered by the subscribers, and the components of the traffic are the arrival rate and service time shown in Fig 2.

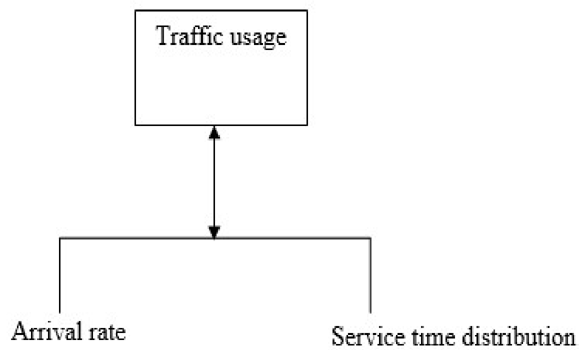

Fig. 2. Traffic random components

During the course of random distribution, with the time being quantities differ in a way that instant worth attached with quantity may be predicted with some certainty. Such quantities are described as random variables [16]. A traffic user demands component is made up of the arrival rate and service time distribution which is modelled by statistical properties [17], [18], [19].

Arrival Rate in Communication

The Arrival process is described as the rate of subscribers in which he reaches at the service facility with the time period specified. Although, the rate of arrival may be counted with the help of counting the sum of subscriber with specified period of time. It is hypothesized that arrivals rate is independent of each other and may randomly change over the period of time. Arrival rate is calculated as number of calls in mobile communication. The Greek word Lambda (λ) is referred to denote arrival rate [17]. The arrival rates at the service facility conform to probability distribution, such as Poisson distribution, Exponential distribution and Erlang distribution [20]. Arrival process is the input of queue system which is characterized by these components as follows [21], [22]. The size of the calling population, behavior of arrivals and pattern arrival at the system, depend on the arrival processes in queuing system which can be analyzed either by the average arrival rate (average number of arrivals per unit of time) or by the average inter-arrival time (average time between two consecutive arrivals).

The number of unscheduled arrivals to a service facility in some fixed period of time can be studied by a statistical probability distribution such a Poisson distribution [18]. The arrival process distribution can be approximated by one of the following probability distributions as follows: Poisson distribution, Exponential distribution and Erlang distribution [20], [23].

Service Time Distribution

The time taken by the server (mobile equipment), from the commencement of service to the completion of the service for a customer is known as the service time. It is also taken into consideration as the communicate time or name's period, call overhead time, plus queuing time if any. (Call length and ready time) the overall time needed to serve a purchaser that required carrier in system. The service time indicates the amount of time needed to service a customer. A fluctuating service time may follow exponential probability distribution. The service is provided by a service facility (or facilities). This may be a person (a Bank teller, a Barber, a Machine) or space (airport runway, parking lot, hospital bed) and it may include one person or several people operating as a team [20], [21] [23]. There are two basic aspects of a service system. These configurations are based on service system and speed of the service [20]. These configurations of the service show how the service facilities exist (on the number of channels, or number of servers). The different types of service system configuration are single server-single queue, single server-several queues, several (parallel) servers-single queue, several servers-several queues and service facilities in a series. In a queuing system, the speed with which service is provided can be expressed in two ways as follows [20]. The service rate describes the number of customers serviced during a particular period of time and the service time indicates the amount of time needed to service a customer.

Statistical Property

The arrival process, at the telecommunication exchange (switches) can be described using mathematical random point process or counting process. The description of point processes is as follows. Point process has two basic properties, which include:

- Orderliness is the possibility that two or extra arrivals manifest without delay are negligible.
- Memoryless is defined as, in any factor in time, the destiny evolution of the method is statistically unbiased of its past. The two houses are possessed by means of Markovian theory or Markovian chain.

The drawbacks associated with mobile communication are stochastic in nature; therefore, the reliability of the mobile communication is important.

RELATED WORK

Lee Ee foong et al., considered the behavior of radio signal for indoor and outdoor environment, while Thomas Locher et al. considered the users present logical position. Yasamin Mostofi and Pradeep Sen also built a map of the received signal strength to a fixed station and a successive interference cancellation method. The level of Received Signal Strength experienced in mobile communication networks in Nigeria is considered in this study. In addition, speech quality was also being considered in this study. Firstly [7] considered speech quality measurement in GSM networks using Perceptual Evaluation of Speech Quality (PESQ) while [24] developed parametric models to estimate MOS speech level, subjective method was deployed to determine the speech quality in mobile communication networks under investigation [7], [24].

METHOD AND MATERIALS

Evaluation of Mobile Communication Network Performance in Nigeria was considered in this study. Firstly, quality of service parameters was highlighted and determined based on the data obtained from OMC from various networks such as NET A, NET B and NET C. The quality of service considered dropped calls, blocked calls, speech distortion and Received Signal Strength (RSS). The Received Signal Strength (RSS) is measured in decibels and subjective speech measurement method using MOS was carried out in the Ambrose Alli University Campus, Ekpoma for a period of one year from June 2014 to July 2015.

The speech quality is determined at a quiet place at various times and different periods using the recommended sentences have been recommended by ITU-T standard. The recommended sentences are as follows: you will have to be very quiet, there was nothing to be seen, they worshipped wooden idols, I want a minute with the inspector and did he need any money. Male and female speech voices were used in this analysis for a period of one year.

Five types of TECNO mobile equipment, with model number TECNO N3, and Andriod Version 2.3.5, were used in the three mobile communication networks. The RSS was determined using network monitor software installed in TECNO N3 to determine RSS level at six different locations such as Twin Hall, Environmental Junction, Law Build, Library Build, AAU Gate, and AAU Hostel, with the corresponding signal strength and both latitude and longitude, for the three mobile communication networks. Statistical tools such as RMSE and Correlation Coefficient were used to evaluate the speech quality on mobile communication networks and the relationship between male and female speech quality.

While Empirical model was developed based on the RSS obtained from three mobile communication networks. The chi-square goodness of fitness was also deployed to determine the correction between signal strength and recommended benchmark. In addition, MSE value was evaluated based on the Empirical model developed.

Data Presentation

Three different mobile network operators in Nigeria were considered in this investigation. Firstly, the accumulative causes of dropped calls were presented in Table 1.

TABLE 1
VARIOUS CAUSES OF DROPPED CALLS FROM THREE NETWORKS WERE HIGHLIGHTED

S/N	Causes of dropped calls	Average Occurrence
1	Forceful termination due to speech distortion	56
2	InsuffiClient Credit	32
3	Electromagnetic causes	21
3	Battery outage	10
4	Handover process	5

The subjective measurement method of three different mobile network operators in Nigeria, using Mean Opinion Score values with recommended sentences was shown in Table 2.

TABLE 2
THE MOS RESULTS OBTAINED FROM INITIALING CALLS FROM THE BASIC THREE NETWORKS

S/N	Recommended Sentences from ITU-T	MALE									FEMALE								
		Net A to Net A	Net A to Net C	Net A to Net B	Net B to Net A	Net B to Net C	Net B to Net B	Net C to Net A	Net C to Net C	Net C to Net B	Net A to Net A	Net A to Net C	Net A to Net B	Net B to Net A	Net B to Net C	Net B to Net B	Net C to Net A	Net C to Net C	Net C to Net B
1	You will have to be very quiet	4.7	5.0	4.0	5.0	4.3	4.7	4.0	4.0	4.3	4.7	5.0	5.0	5.0	4.3	4.7	4.7	5.0	4.3
2	There was nothing to be seen	4.7	4.3	4.7	5.0	4.0	4.7	4.3	4.0	4.0	5.0	5.0	5.0	5.0	5.0	5.0	4.7	5.0	5.0
3	They worshipped wooden idols	4.7	4.7	5.0	4.7	3.3	4.7	3.0	3.0	3.3	4.0	4.7	4.3	4.7	4.3	4.0	4.3	3.6	4.3
4	I want a minute with the inspector	5.0	5.0	4.3	5.0	4.3	5.0	4.0	4.6	4.3	4.7	5.0	5.0	5.0	4.3	4.7	4.7	5.0	4.3
5	Did he need any money	5.0	3.6	4.3	4.7	4.7	5.0	5.0	4.3	4.7	4.3	4.7	4.7	4.7	4.0	4.3	5.0	4.3	4.0

TABLE 3
THE RECEIVED SIGNAL STRENGTH (RSS) DBM OBTAINED AT AAU CAMPUS, EKPOMA

S/N	Investigated location position	Received Signal Strength (RSS) DBm			Mobile Latitude	Mobile Longitudes
		NET A	NET B	NET C		
1	Twin Hall	-59	-92	-59	6^0 44' 5.5"	6^0 4'51.2"
2	Environmental Junct.	-73	-89	-71	6.44'57.23"	6.4' 48.09"
3	Law Build	-95	-97	-77	6^0 43"52.0"	60 4'42.6"
4	Library Build	-67	-89	-69	6^0 44'57.4"	60 5'9.2"
5	AAU Gate	-97	-79	-91	6 44'37.3"	6^0 52.9'
6	AAU Hostel	-63	-81	-107	6^0 44' 14.8'	$6^0$4' 46.8"

DATA ANALYSIS, RESULTS AND DISCUSSION

Firstly, various causes of dropped calls in Nigeria were considered from Network A, it was observed that forceful termination due to speech distortion has resulted in the highest dropped call occurrences in mobile communication networks.

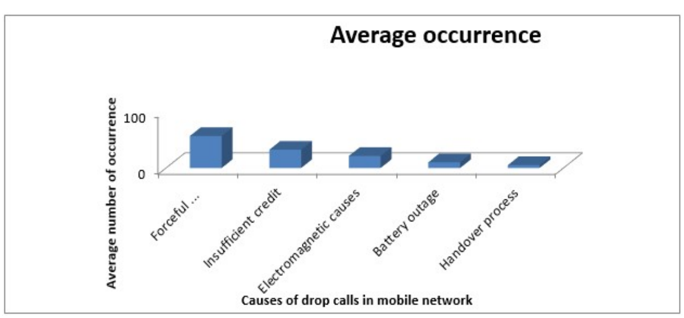

Fig. 3. The causes of dropped calls and level of occurrences in mobile communication networks

The dropped calls affect the quality of service leading to increase in number of redial calls and traffic congestion in mobile communication networks. Therefore, the needs to evaluate the speech quality become imperative, using the subjective measurement method which is based on MOS values shown in Table 2. Statistical tools such as RMSE also called the root mean square deviation presented in Equation 1, were used to measure the difference between values predicted by a model and the values actually observed from the environment that is being modeled.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(X_{Obs,i} - X_{MODEL,i})^2}{n}} \quad (1)$$

Where X_obs is the observed value and Xmodel is the modeled value at the time and place i.
X_Obs is assumed to be MOS calls values obtained from Network A to Network A mobile communication networks, while n is the number of occurrences. Also, X_{Model} is assumed to be MOS calls values from Network A to either Network B or Network C mobile communication network.

The RMSE value obtained from MOS values from Network A to Network C is 0.559
While the RMSE value obtained from MOS values from Network A to Network B is 0.665
The average RMSE value obtained from MOS values from Network A = 0.612
The RMSE value obtained from MOS values from Network B to Network C is 0.7987
The RMSE value obtained from MOS values from Network B to Network C is 0.2324
Similar, the average RMSE value obtained from MOS values form Network B = 0.51556
The RMSE value obtained from MOS values from Network B to Network C is 0.5916
The RMSE value obtained from MOS values from Network C to Network B is 0.7563
Also, the average RMSE value obtained from MOS values for Network C = 0.674

The total average RMSE value obtained from MOS values for male speech quality is given as:

The total average RMSE value obtained from MOS value $= \frac{(0.612+0.516+0.674)}{3} = 0.601$
The coefficient r=

$$\frac{\sum_{i=1}^{n}(X_i - \bar{X}).(Y_i - \bar{Y})}{\sqrt{\sum_{n}^{i=1}(X_i - \bar{X})^2.(Y_i - \bar{Y})^2}} \quad (2)$$

The correlation coefficient was deployed from Equation (2) to determine the strength and the linear relationship between male and female speech quality level based on the same networks
Where Xi = Male
While Yi = Female
Average male value obtained from MOS value $\bar{x}$ = 4.82
Average female value obtained from MOS value $\bar{y}$ = 4.54

The Correlation Coefficient (r) values obtained from various networks were 0 (zero) MOS value. This implies that the male speech quality was in variance with female speech quality level. This comparison between male and female speech quality level is shown in Fig 4 and Fig 5. The cumulative MOS values for both male and female obtained from the three mobile networks, such has Net A, Net B, and Net C, were compared in Figure 4.

It observed that female speech sounds better than the male counterparts' speech.

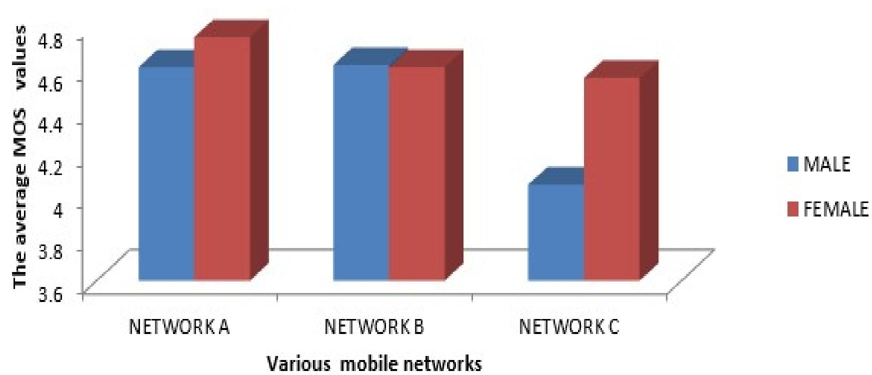

Fig. 4. The causes of dropped calls and level of occurrences in mobile communication networks

Also, in Figure 5, it was observed again that the female voice sounds better with 51%, while the male speech quality is 49%, based on calls initialed from network A, to other mobile communication Networks.

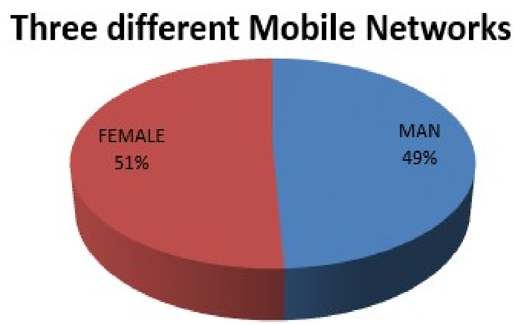

Fig. 5. Comparison of male and female speech quality based on the MOS values obtained with recommended ITU sentences

In Figure 4 and 5, it is shown the corresponding average MOS values comparison of various networks for both male and female speech quality level on different mobile communication networks under investigation. It is observed that on Net A, average MOS value obtained is 4.67 for both male and female speech quality level, on Net B, average MOS value obtained is 4.605 for both male and female speech quality level, while on the Net C, average MOS value is 4.3 for both male and female speech quality level, which implies that the MOS values obtained for various mobile networks is good and satisfactory, but the mobile operators need to still improve on the speech quality level. From Table 2 shown in Fig 4, it was observed from the male speech, that low values were witnessed, resulted to low (poor) speech quality from calls initialed from Net C to Net C.

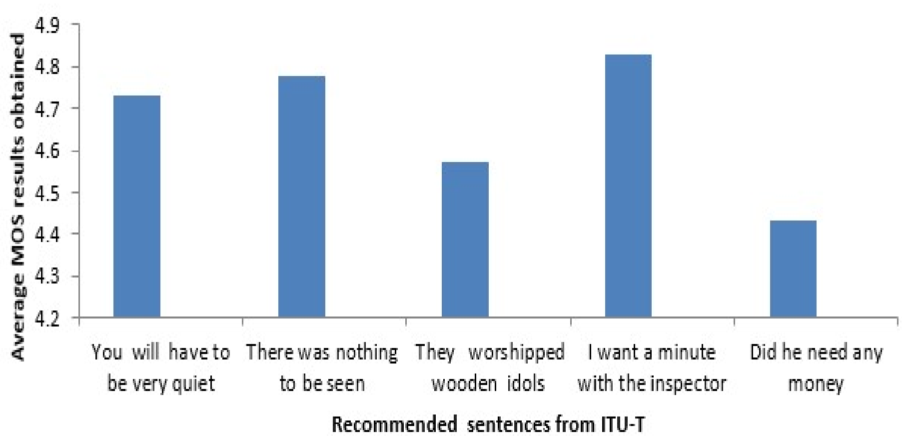

Fig. 6. Various subjective recommended ITU sentences

It is observed from Fig. 6, based on the recommended ITU sentences, that there are still discrepancies which exist among the five recommended sentences. But three of the recommended sentences reflect close correlation, while two sentences show wide variation with the initial three sentences in Fig. 6. Therefore, those sentences should be reconsidered for the purpose of speech quality analysis. The dangers of this are that subjective speech method consumes extra time because of the high number of listeners required to perform the test. The objective methods try and cast off those problems and introduce a human unbiased approach to speech first-class. This may be achieved through mathematical computational fashions and algorithms. However, the objective measures are widely used since they have several critical advantages over the subjective measures. Also, for further study, the subjective measurement result should be compared with objective method. In addition, the various parameters that affect or cause low speech qualities are highlighted as follows: channel noise, interferences, echo, codec used, speech level, noise level, Mobile Terminal (MT) or Mobile Station (MS), Frame-Erasure Rate (FER), Discontinuous Transmission (DTX), and handover rates and bit error ratio. In addition, there are speaker dependent parameters including pitch, speaking rate and accent.

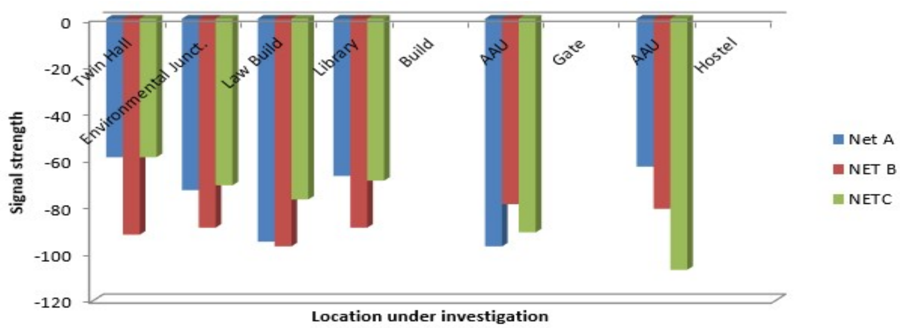

Fig. 7. The Received Signal Strength (RSS) dBm for three different mobile network operators

The Received Signal Strength (RSS) in dBm for the three different mobile network operators under investigation was presented in Figure 7, the data were obtained using network monitor software installed in TECNO N3 to determine RSS level at six different locations such as Twin Hall, Environmental Junction, Law Build, Library Build, AAU Gate, and AAU Hostel, with the corresponding signal strength and both latitude and longitude, for the three mobile communication networks. The comparison was based on the six locations investigated in AAU campus presented in Fig. 7. Also, from the graphical presentation, it was observed that the Net A's signal strength is more linearly distributed compared to other GSM networks with a value of 0.043 MSR. This implies that, the signal strength value remained (strong) constant, despite the external factors and obstacles under the area investigated. In addition, Net B's maintenance is strong and has constant signal strength over the distance investigated. It is observed that there is gradual depreciation of signal strength level in Net C shown in Fig. 7 due to attenuation experienced from obstacles, reflections and diffraction of the received signal strength at the Mobile Station (MS) ends. Signal strengths for mobile networks are always negative dBm values, because the transmitted network is not strong enough to give positive dBm values. Recommended signal strength is -50 dBm, while the obtained average received signal strength from Net A is -75.67 dBm, while Net B at -87.83 dBm and Net C at -79.00 dBm were less powerful (smaller) than -50 dBm presented in Fig. 8. Insufficient signal strength will experience inconsistent audio caused by disconnects, constant audio buffering and regularly signal disappearing from the mobile station.

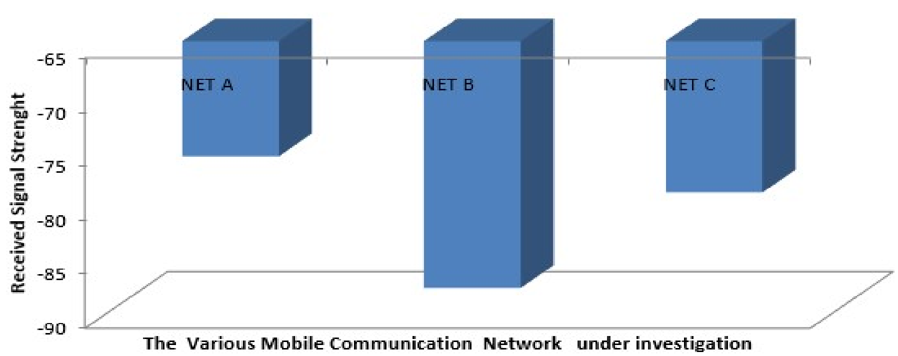

Fig. 8. Comparison of received signal strength from various locations at AAU campus

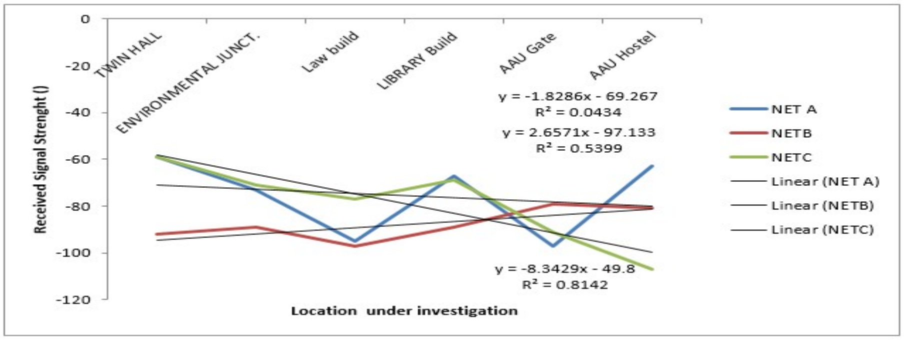

Fig. 9. Linear regression distribution model of RSS for the three networks under investigation

Empirical Model of Received Signal Strength

The empirical approach is based on measurement of data that when plotted as regression curves or analytical expressions can be used to calculate signal levels. The advantage of empirical model is that it is a measurement basis, they all take into account known and unknown factors of radio propagation. The Microsoft excel tool was used to determine empirical model based on various mobile communication networks' Received Signal Strength pattern based on locations under investigation. It was observed that the Mean Square Root (MSR) least value obtained is from linear distribution for NET A, with 0.043, followed by Net B and Net C, from Fig. 9 presented in Table 4. The linear distribution was compared with logarithmic and polynomial distribution with their respective values.

TABLE 4
THE MOBILE COMMUNICATION NETWORK EMPIRICAL MODEL DISTRIBUTION PATTERN WITH MEAN SQUARE ROOTS

S/No	Networks Operators	Mean Square Roots		
		Linear Distribution	Logarithmic Distribution	Polynomial Distribution
1	Net A	0.043	0.122	0.425
2	Net B	0.539	0.388	0.654
3	Net C	0.814	0.697	0.870
	Mean value	0.465	0.402	0.650

The empirical model obtained is presented in Equation 3, based on Received Signal Strength obtained from investigated networks corresponding to Net A shown in Table 4 and the relative Mean Square Error (MSE) of 0.043.

$$Y = -1.828x - 69.26 \quad (3)$$

R_2 = 0.043

In statistics, linear regression is an approach for modeling the relationship between a scalar dependent variable y and one or more explanatory variables denoted by X. The linear regression distribution model is expressed in Equation 3, where y represents the various locations (distance), while x represents the signal strength. However, based on Okumura, it is stated that the signal strength decreases at much greater rate with distance than that predicted by free space loss. It was observed that Net A signal strength is more linearly distributed compared to Net B and Net C networks with a value of 0.043 MSR. This implies that, the Net A signal strength value remained (strong) constant, despite the external factors and obstacles under the area investigated.

The linear distribution of received signal strength obtained in this study was in line with the theory; this is to enable active subscribers within the cell to be effectively covered by the mobile network. In addition, Net B and Net C experienced attenuation due to obstacles, reflections and diffraction of the received signal strength at the Mobile Station (MS) ends, result to logarithmic distribution of RSS, based on total least average or mean value obtained from logarithmic distribution of 0.402.

CONCLUSION AND RECOMMENDATIONS

However, due to dwindling Quality of Service (QoS) witnessed by Nigerian subscribers in mobile communication network, there is need to embark on this study "Evaluation of mobile communication network performance" to determine the causes of low speech quality, blocked calls, dropped call, and Received Signal Strength (RSS) on mobile communication networks. Subjective method using Mean Opinion Score (MOS) was used. Three mobile networks were considered in this study, also the male and female speech quality levels were examined in three different mobile networks Also comparison analysis was carried out between the various networks to determine their speech quality level, using the utilization of different statistical techniques such as Root Mean Square Error (RMSE) and Correlation Coefficient. Additionally, different reasons of dropped calls and signal strength analysis were carried out from three mobile communication network operators in Nigeria, on different sites with the corresponding latitudes and longitudes considered. On average RMSE speech quality value taken by the three networks is 0.601, while correlation value obtained between male and female speech Excellency is in variance. Also, Net A has better speech quality than Network B and Network C. In addition, speech distortion has contributed to high level of dropped calls in mobile communication in Nigeria. It is observed that the average signal strength lies between -50dB and -100dB, it is observed that Net B has the highest average sign strength, followed by Net C and Net A. The most suitable received signal strength from the investigation is of Net A because the average signal strength value obtained is 75.7dBm followed by Net C network. Also, it was observed that Net A's signal strength possesses linearly distributed characteristics compared to Net B and Net C networks with a value of 0.043 MSR. This implies that, the Net A's signal strength value remained (strong) constant, despite the external factors and obstacles under the area investigated.

Declaration of Conflicting Interests

There are no conflicts of interest in this study.

REFERENCES

[1] O. A. Osahenvemwen and J. Emagbetere, "Traffic analysis in mobile communication in Nigeria," *Journal of Emerging Trends in Engineering and Applied Sciences,* vol. 3, no. 2, pp. 239-243, 2012.

[2] O. A. Osahenvemwen, F. O. Edeko and J. Emagbetere, "The effects of ostentatious calls in GSM networks," *International Journal of Computer Applications,* vol. 48, no. 9, pp. 33-37, 2012.

[3] B. Haider, M. Zafrullah and M. K. Islam, "Radio frequency optimization & QoS evaluation in operational gsm network," in *Proceedings of the World Congress on Engineering and Computer Science,* vol. 1, pp. 1-6, 2009.

[4] J. G. Beerends, A. P. Hekstra, A. W. Rix and M. P. Hollier, "Perceptual Evaluation of Speech Quality (PESQ) the new ITU standard for end-to-end speech quality assessment part II: Psychoacoustic model," *Journal of the Audio Engineering Society,* vol. 50, no. 10, pp. 765-778, 2002.

[5] A. Srinivasan, "Speech recognition using Hidden Markov model," *Applied Mathematical Sciences,* vol. 5, no. 79, pp. 3943-3948, 2011.

[6] N. Bhatt and Y. Kosta, "Proposed modifications in ETSI GSM 06.10 full rate speech codec and its overall evaluation of performance using MATLAB," *International Journal of Speech Technology,* vol. 14, no. 3, pp. 157-165, 2011.

[7] M. Fajkus, M. Mikulec, M. Voznak, M. Tomis and P. Fazio, "Speech quality measurement of GSM infrastructure built on USRP N210 and open BTS project," *Advances in Electrical and Electronic Engineering,* vol. 12, no. 4, pp. 341-347, 2014.

[8] M. Voznak and J. Rozhon, "Automated speech quality monitoring tool based on perceptual evaluation," in *6th International Conference on Communications and Information Technology. Wisconsin: World Scientific and Engineering Academy and Society (WSEAS),* pp. 95-105, 2012.

[9] R. Verma, S. Mandal and A. Kumar, "Improved voice quality of GSM network through voice enhancement device," *International Journal of Advanced Research in Computer Science and Software Engineering,* vol. 2, no. 7, pp. 77-80, 2012.

[10] VoIP Mechanic. (2015). *MOS- Mean Opinion Score for VoIP Testing* [online]. Available: https://goo.gl/1BZuv7

[11] S. Bhandare and M. R. Dixit, "Positioning of mobile in GSM network using received signal strength," *International Journal of Computer & Communication Engineering Research,* vol. 1, no. 2, pp. 56-58, 2013.

[12] S. Helhel, S. Ozen and H. Goksu, "Investigation of GSM signal variation depending weather conditions," *Progress in Electromagnetics Research B,* vol. 1, pp. 147-157, 2008.

[13] P. Saveeda, E. Vinothini, V. Swathi and K. Ayyappan, "Received Signal Strength (RSS) calculation for GSM cellular system at BSNL Pondicherry using modified HATA model," *International Journal of Science, Engineering and Technology Research,* vol. 2, no. 1, pp. 43-7, 2013.

[14] O. O. Shoewu and L. A. O. Akinyemi, "The effect of climatic change on GSM signal propagation," *Research Journal of Computer Systems Engineering,* vol. 4, no. 2, pp. 471-478, 2013.

[15] Wikipedia. (n.d). *Signal strength in telecommunications* [online]. Available: https://goo.gl/IqGa5E
[16] S. Sanjay, *Computer Networks,* 1st ed. New Delhi, India: S. K. Kataria and Sons, 2010, pp. 621-629.
[17] S. Kyriazakos, N. Papaoulakis, D. Nikitopoulos, E. Gkroustiotis, C. Kechagias, C. Karambalis and G. Karetsos, "A comprehensive study and performance evaluation of operational GSM and GPRS systems under varying traffic conditions," in *IST Mobile Summit,* Thessaloniki, Greece, June 17-19, 2002.
[18] International Telecommunication Union (ITU). (2010). *Teletraffic Engineering* [Online]. Available: https://goo.gl/lsZEm
[19] C. I. De Mattos, E. P. Ribeiro and C. M. Pedroso, "A new model for VoIP traffic generation," in *The 7th International Telecommunications Symposium,* 2010.
[20] L. Sharma, *Operation Research Theory and Application.* India: Macmillan Publishers India Ltd, 2010.
[21] C. Balint, G. Budura and A. Budura, "Mixed traffic models for dimensioning radio resources in GSM/GPRS networks," *WSEAS Transaction on Communications,* vol. 9, no. 3, pp 233-242, 2010.
[22] S. Belhaj and M. Tagina, "Modeling and prediction of the Internet end-to-end delay using recurrent neural networks," *Journal of Networks,* vol. 4, no. 6, pp. 528-535, 2009.
[23] W. A. Massey, "The analysis of queues with time-varying rates for telecommunication models," *Telecommunication Systems,* vol. 21, no. 2, pp. 173-204, 2002.
[24] M. Barile, P. Camarda, R. Dell'Aquila and N. Vitti, "Parametric models for speech quality estimation in GSM networks," in *International Conference on Software in Telecommunications and Computer Networks,* pp. 204-208, Sept. 29- Oct. 1, 2006.

— This article does not have any appendix. —